Title: Regressive Music

Brief Overview:

Students will use the TI-83 calculator and the CBL microphone probe to plot a sinusoidal graph determined by the vibrations of a tuning fork. Using their knowledge of the trigonometric equation

$$y = a \sin b(x-c) + d$$

the students will change values of the variables to try to create a curve of best fit. Once they have determined their curve, the students will use the sine regression on the TI-83 to find the curve that best fits the data. Students will compare their curve of best fit to the one given by the calculator.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will use the TI-83 graphing calculator and the CBL to collect and analyze data. They will then make conclusions based on manipulations of the collected data.

- **Mathematics as Communication**
  The students will interactively discuss how to manipulate the variables in the equation. The students' result will be expressed both orally and in written form.

- **Mathematics as Reasoning**
  Students will make conjectures, test their conjectures, and make modifications based upon new results.

- **Mathematical Connections**
  Students will recognize how changing the variables in the equation for the sine curve affects the period and the amplitude of the graph of the equation.

- **Computation and Estimation**
  Students will estimate the magnitude of each coefficient to use in the sine equation in order to correctly match the data.

- **Algebra**
  Students will use graphing as a tool to analyze data.

- **Functions/Trigonometry**
  Students will represent the trigonometric sine function graphically.

- **Statistics**
  Students will use curve fitting.

Grade/Level:

9-12, Advanced Algebra II or Pre-Calculus/Trigonometry

Duration/Length:

One class period, with extensions extending into additional periods

Prerequisite Knowledge:

Students should:

- understand the following terms: period, amplitude, horizontal shift, vertical shift.
- be able to graph a sine curve from the following equation: $y = a \sin b(x-c) + d$.
- be familiar with entering and graphing equations on the TI-83.
- be familiar with using the TI-83 to find the x-intercept of a graph and tracing a graph.

Objectives:

Students will:

- collect data using a CBL and microphone probe.
- manipulate input to determine the most appropriate sine function to represent the data collected.
- use the sine regression function on the TI-83 to determine the curve of best fit for the collected data.
- use the parameters from the regression function to plot the curve of best fit.

Materials/Resources/Printed Materials:

- The Sound program (vernier version) for the TI-82/83
- TI GraphLink to transfer Sound program.

For each student group:

- CBL and microphone probe
- Link cable
- Tuning fork
- TI-83 calculator

Development/Procedures:

- Download the Sound program onto all of the TI-83 calculators to be used.
- Divide students into groups of 3 or 4.
- Distribute the CBL and microphone probe to each group along with worksheets.
- Have students follow self-directed worksheets.

Performance Assessment:

- A group evaluation will be given based on quality of discussion, and successful completion of the activity. (See Rubric)
- Labsheet to be completed.

Extension/Follow Up:

- Students can repeat the activity with tuning forks of different frequencies, establishing a relationship between the pitch of the tuning fork and the frequency (or period) of the wave produced.
- Students can use this relationship to predict what the graph of a particular tuning fork will look like, as well as its equation.
- Students can use this relationship to determine the pitch of an unknown tuning fork based on its graph.
- A more elaborate extension with links to science (conservation of energy, energy of a wave) would be for students to determine the relationship between energy imparted to the tuning fork (e.g., by dropping a ball on it) and the amplitude of the resulting wave.

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Regressive Music

I. Setup

Verify that the calculator to be connected to the CBL contains the program SOUND. Connect the calculator to the CBL using the link cable. Connect the microphone to the CBL through the port CH1. Make sure you have a tuning fork.

II. Record the Sound Wave

1. Run the SOUND program on the calculator. [Press PRGM and arrow down to SOUND. Press ENTER twice. You will see the opening screen for the SOUND program. Press ENTER, then turn on the CBL as directed by the TI-83 screen. Press ENTER again on the TI-83. The program will now execute a series of checks to make sure the equipment is connected properly. (If it isn't the program will alert you to the problem and tell you how to fix it.)]
You will be directed to "press ENTER to start collecting data." DO NOT DO THAT YET! (If you pressed ENTER before striking the tuning fork, press CLEAR to remove the unwanted graph.)

2. Strike the tuning fork against your desk, lab table, or the side of the sole of your shoe and hold it near, BUT NOT touching, the microphone, and then press ENTER on the TI-83.

3. If you are not satisfied with your graph, then press CLEAR and repeat the recording, making sure you strike the tuning fork before you press ENTER.

III. Select One Cycle of Your Graph

Once the graph plot is made, you should select one cycle of the graph to analyze. This can be done by the following:
1. Press 2ND LIST OPS 8 (this will choose SELECT from the OPS menu).
2. Designate L2 and L5 as the lists to be shortened. (L2, L5)
3. Press ENTER. The graph screen is displayed. Use the left and right arrow keys, moving the cursor to the left-most point the data to be used.
4. Press ENTER, then move the cursor to the right-most point on the data to be used, and press ENTER again. The lists in L2 and L5 will be shortened and a new stat plot of L2 and L5 will replace the old stat plot.
5. Press ZOOM 9 to get a large graph on the display.

IV. Estimate Values of the Parameters a, b, c, and d

Use the calculator and your knowledge of the properties of the sine curve to estimate the values of the parameters a, b, c, and d to three decimal places. Enter your estimates into the following equation on the y= screen and write the estimates in the spaces provided here:

$$y = \underset{a}{\_\_\_\_\_}\sin\left(\underset{b}{\_\_\_\_}\, x - \underset{c}{\_\_\_\_}\right) + \underset{d}{\_\_\_\_\_}$$

Explain how you made these choices. Your explanation should demonstrate an understanding of each parameter as well as a detailed description of how your group determined each one.

a --

b --

c --

d --

Press the GRAPH key to view the graph of this equation and see how it compares to the graph of the actual data.

Experiment with different values of the parameters until you are satisfied with the fit of the equation to the graph of the actual data. When you are satisfied with the parameters, enter them into the equation in the spaces provided

y = _____ sin(____ x - ____) + _____ .
(a) (b) (c) (d)

V. Regression Analysis

Now it is time for the calculator to provide estimates for the parameters a, b, c, and d.

Press STAT, the right arrow key, ALPHA, PGRM to select the choice C:SINREG: sinusoidal regression. When SINREG appears on the screen type in 16, L2, L5, and press ENTER. The calculator will display values for a, b, c, and d as well as a measure of how "close" the fit is.

Fill in the following equation using the values rounded to three decimal places:

y = _____sin(____ x - ____) + _____
a b c d

Then press graph. Now that you have all three graphs (the actual data, your best fit, and the calculator's best fit), you should save a picture of them (If you don't have all three showing now make sure equations 1 and 2 are turned on on the y= screen and stat plot 1 is turned on also). Press 2ND PGRM to get to the DRAW menu. Use the arrow key to highlight the STO option and press ENTER to select StorePic. Press 1 to save the graphics as Pic 1.

Now use the GraphLink to copy and print the screen. Attach the printout to this paper. Be sure to indicate the scale on each axis and identify which graph is:
1. the stat plot (of the actual data)
2. the graph based on your parameters
3. the graph based on the calculator's parameters.

Congratulations!

SCORING RUBRICS

GRAPHS

3 pts.	All three graphs printed including scale and labels.
2 pts.	All three graphs including scales or labels.
1 pts.	All three graphs, no scales or labels.
0 pts.	No graphs.

EXPLANATION

3 pts.	Demonstrates an understanding of parameter and a logical way to determine it.
2 pts.	Provides adequate explanation, missing some detail.
1 pts.	Provides explanation with little understanding.
0 pts.	No explanation.